Periodic Report

on the Grant:

APPLICATION OF PANEL METHODS TO V/STOL AND SLENDER BODY AERODYNAMICS.

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by

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INTRODUCTION

The focus of this research over the past years has been placed on the development of potential flow based panel methods and on the expansion of their applicability to a variety of V/STOL aircraft related problems. This effort resulted in the development and refinement of the panel code PMARC, which was achieved partially by the active involvment of SDSU graduate students, who were supported by this grant. Past graduate student projects included elements of code validation as well, and dealt with topics such as wind tunnel wall correction, wake rollup simulation, wing rock, and recently, the relative motion between two airplanes. Parallel to the numerical effort, several wind tunnel experiments were also conducted, primarily to provide test cases for the computer code validation. This combined numerical/experimental effort led to numerous publications which were presented in the AIAA and SAE professional conferences (see Refs. 1-11).

The research progress is briefly summarized in the following paragraphs and more technical details are presented in the publications listed at the end of this report. These publications consist the technical part of this document and a copy of each was sent to the technical monitor of this grant.

RESEARCH PROGRESS

The interactive process of configuration development and aerodynamic performance optimization requires the balanced utilization of experimental, computational and analytical methods. Because of the nonlinear nature of the aerodynamic problems, current analytical or experimental prediction methods are still limited, and the combined use of these technologies helps in providing a more complete vehicle-performance estimation. In view of this assumption, the current research has elements of code application and development, and numerical and experimental validation. The research progress in past years of this Grant, are briefly summarized in the following sections:

1. Panel Code Development and Validation:

a. Study of the modeling of close aerodynamic interference problems, such as multi-element, high-lift airfoils: under this category several high-lift wing sections were investigated, experimentally and numerically. Also, comparisons were made with SDSU wind tunnel data to investigate the range where the panel code predictions are acceptable from the engineering point of view. Some of the first results have been summarized and published in the AIAA Journal (see Publication No. 1).

b. Modeling of time-dependent flow fields: to study this problem the panel geometry of the standard dynamic model was prepared and results of this investigation were published by the J. Aircraft (see Publication No. 2). Cases involving relative motion between the solid body components (e.g. a propeller rotating relative to the fuselage) were investigated too, and the first results are summarized in Publications No. 3 and No. 11. In the search to improve the mathematical algorithm of panel methods, the numerical implementation of the Kutta condition was examined (these findings were summarized in Publication No. 4)

c. Computations of the loads on a rapidly pitching delta wing were made for comparison with results obtained in the NASA Ames 7 by 10 foot wind tunnel. This work was presented at ASME International Symposium on Nonsteady Fluid Dynamics, Toronto, Canada, June 4-7, 1990 (see Publication No. 5).

d. Utilization of panel codes for low-speed wind-tunnel correction was studied on a variety of configurations and an SAE paper was presented on this topic in January 1989, and at the AIAA meeting in Reno, Nevada Jan. 1990 (see Publications 6, and 7).

2. Experimental Effort to Support Code Validation:

a. Design and development of a free-to-roll wind-tunnel sting-mount for "Wing-Rock" or "Tumbling" experiments was completed. This effort resulted in two publications (Refs. No. 8 and 9). The effect of vertical, lifting jets on the performance of a landing V/STOL airplane was investigated with a slender delta wing and the results of this study are reported in Publication No. 10.

PUBLICATIONS

The technical results of this research are summarized in the following publications. The conference papers of Refs. 10-11, and the corresponding journal articles (that were accepted for publication) comprise the technical summary of last year's effort.

1. Katz J. "Aerodynamics of High-Lift, Low Aspect-Ratio Unswept Wings", AIAA J., Vol. 27, No. 8, 1989, pp.1123-1124.

2. Katz J. "Numerical Simulation of Aircraft Rotary Aerodynamics", AIAA Paper 88-0399, and J. Aircraft, Vol. 26, No. 7, 1989, pp. 692-693.

3. Yon. S, Katz J, and Ashby D., "Unsteady Fluid Dynamic Model for Propeller Induced Flow Fields," AIAA Paper No. 91-1664, June 1991.

4. Yon. S, Katz J, and Plotkin A., "Effect of Airfoil (Trailing-Edge) Thickness on the Numerical Solution of Panel Methods Based on the Dirichlet Boundary Condition," AIAA J., Vol. 30, No. 3, pp. 697-702, 1992.

5. Ashley H., Katz J., Jarrah M. A., and Vaneck T., "Survey of Research on Unsteady Aerodynamic Loading of Delta Wings," Journal of Fluids and Structures, Vol. 5, pp. 363-390, 1991.

6. Katz J. "Integration of Computational Methods into Automotive Wind Tunnel Testing", SAE Paper 89-0601, presented at the SAE Int. Conference, Feb. 1989.

7. Browne L., and Katz J. "Application of Panel Methods to Wind-Tunnel Wall Interference Corrections," AIAA Paper No. 90-0007, Jan. 1990.

8. Katz J. and Levin D. "Static Measurements of Slender Delta Wing Rolling Moment Hysteresis", J. Aircraft, Vol. 28, No.4, 1991, pp. 282-283.

9. Levin D. and Katz J., "Self Induced Oscillations of Low Aspect Ratio Rectangular Wings," AIAA 90-2811, presented at the AIAA Atmospheric Flight Mechanics Conf., Aug. 1990. Also, J. Aircraft, Vol. 29, July-August 1992, pp. 698-702.

10. Katz J., and Walton J., "Control of Wing Rock Using Leading-Edge Vortex Manipulations," AIAA Paper No. 92-0279, presented at the AIAA Aerospace Sciences meeting in Reno, 1992. A slightly different version will be published by the J. Aircraft in 1993.

11. Richason, F. T., Katz, J., and Ashby, Dale, "Unsteady Panel Method for Flows with Multiple Bodies Moving Along Various Paths," AIAA Paper No. 93-0640, presented in Reno, Jan. 1993. Also, accepted for publication by the AIAA J. 1993.